

MAMMOTH CAVE SALTPETER WORKS  
Mammoth Cave National Park  
Mammoth Cave  
Edmonson County  
Kentucky

HAER NO. KY-18

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HAER  
Ky.  
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HISTORIC AMERICAN ENGINEERING RECORD

MAMMOTH CAVE SALTPETER WORKS

HAER No. KY-18

Location: Mammoth Cave: The Rotunda and Booth's Amphitheatre  
Mammoth Cave National Park  
Edmonson County (formerly part of Warren County)  
Kentucky

UTM: 16:4115805.579615 (Historic Entrance)  
Quad: Mammoth Cave, Kentucky

Date of Construction: Circa 1810

Present Owner: United States Department of the Interior  
National Park Service

Present Use: Public display and interpretation of saltpeter processing  
as part of Mammoth Cave National Park

Significance: Mammoth Cave Saltpeter Works represent the most complete  
example known of the equipment used in the processing of  
cave saltpeter, a major component of gunpowder during the  
War of 1812. The works were constructed in their present  
form while under the ownership of Charles Wilkins of  
Lexington, Kentucky, and his partners, Fleming Gatewood  
of Warren County, Kentucky and Hyman Gratz of  
Philadelphia. The saltpeter manufactured here, perhaps  
as much as 115,000 pounds during 1814, was sold to  
eastern gunpowder manufacturers to meet American military  
needs. The works were abandoned about 1815, at the end  
of the war. Presently nine leaching vats, two collecting  
tanks, a portion of one pump, about fifty sections of  
wooden water pipe, and several pumptower timbers remain.

Project Information: This project was undertaken during the summer of 1986 by  
the Historic American Engineering Record (HAER) in  
cooperation with Mammoth Cave National Park and the  
Southeast Preservation Center, National Park Service.  
Members of the Cave Research Foundation (CRF) assisted in  
the fieldwork and reviewed drafts of this report. Park  
historians and interpreters also reviewed the drawings  
and report. The generous assistance and liaison of the  
foundation and the park contributed substantially to the  
success of this project.

Report Prepared by: Marsha A. Mullin  
Project Historian  
Mammoth Cave Saltpeter Works Recording Project  
Summer 1986

In 1836, Robert Montgomery Bird visited Mammoth Cave in south central Kentucky. His first impression of the cave was not of its natural wonders, but of some wooden beams and two tottering stone chimneys, "the ruins of the old saltpeter works, the manufacture of which villianous compound in the last war [War of 1812] was carried on to great extent in the cave."<sup>1</sup> What Bird saw was the remains of one of the most extensive saltpeter mining and processing operations active during that war. Since saltpeter processing ceased at the end of the war, tourists have continued to visit the cave, making Mammoth Cave National Park the tenth most visited park in the National Park System. The saltpeter works inside the cave were an important landmark on early tours and continue to be an important feature of Mammoth Cave tours today. Most of today's visitors know nothing about saltpeter and probably find it difficult to associate the wooden structures inside the cave with an advanced chemical process. But the large quantities of saltpeter processed from the earth of Mammoth Cave and sold to eastern gunpowder manufacturers, primarily E.I. du Pont de Nemours and Company, contributed materially to the American cause during the War of 1812.

#### Description of the Site

Although the remains of the works are inside the cave, the surrounding surface area contributed to successful saltpeter production. The cave is part of the world's longest cave system, formed by underground rivers cutting through the limestone of the Mammoth Cave Plateau. This area, bordering the Green River, was covered by oak and hickory forests. Nearby is the Sinkhole Plain, called "the Barrens" by early travellers because it was a nearly treeless prairie. It is an area dotted with shallow depressions, sinkholes where surface water filters underground. Mammoth Cave became a National Park in 1941 and though the land in the area was once largely cleared, it has been allowed to return to forest, since acquisition by the National Park Service.

Saltpeter was made in the vicinity of the "Historic Entrance." Earth mining and leaching took place inside the cave, and chemical conversion and crystallization were done outside. The cave entrance is located two tenths of a mile down hill from the Visitor Center and is approached by a paved roadway through a wooded area. This road probably covers the site of some of the surface activities associated with the saltpeter works. There is no visible evidence of these activities today, although furnace foundations and ash piles are reported to have been visible in the 1930s.<sup>2</sup>

The natural entrance to Mammoth Cave is a large stone arch overhung with foilage. The area in front of the cave entrance has been paved and has stone bench seating for tour groups. A concrete stairway with metal handrail allows visitors to make the 45 foot descent into the cave and a small waterfall falls to the left of the stairway and drains into a filled-in sinkhole. As with the structures associated with surface activities nothing remains of the water collecting tank or water lifting system which once were located at the cave entrance.

Upon entering the cave, one gets the impression that little has changed since the time of the saltpeter works. Mammoth Cave is a limestone cave with a sandstone caprock which prevents water from dripping into the cave. This means that this area of the cave has no formations such as stalactites and stalagmites. The air inside the cave is humid and the temperature remains constant at 54 degrees. Neither blasting nor drilling have been done to change the walls or passages, although several new entrances have been blasted in areas well away from the historic entrance.<sup>3</sup> However, some changes have been made primarily to accommodate tourists. The cave was electrified in the 1950s, railings have been installed, and the trail has been modified many times, most recently in 1966-67. Pathways have been cleared of rocks and smoothed over, and rock walls built by the saltpeter workers taken down (see attached map of this area of Mammoth Cave).

Along the entry passage, a wide, low-ceilinged, 600 foot long corridor called Houchins Narrows, two sets of wooden water pipes buried along the right wall, are the first visible evidence of the saltpeter works. These pipes, made of bored out tulip poplar logs, connected with a spigot and socket joint and constricted by an iron band, are just visible above the surface of the soil.

In the first big room of the cave, the Rotunda, are the remains of the first leaching station. There is a pump and pumptower, water collecting tank, and three wooden leaching vats arranged in a semi-circle with the collecting tank in the center, as well as various pieces of wood pipe, and mounds of soil. This leached out, or lixiviated dirt, was piled up by the saltpeter laborers emptying the vats. So much of this earth was piled up that today it appears that a pit was dug deep into the dirt on the floor of the cave for the leaching vat complex. However, the vats are located at the original cave floor, while today's elevated pathways were built on huge quantities of dirt shoveled out of the vats.

The Rotunda is a large room, about 44 feet above the floor of the collecting tank, with a clear spanning stone ceiling running 120 feet from east to west. Three posts and four diagonal braces of the pumptower stand around the rectangular water collecting tank which is 3' 2-1/2" x 10' 1" x 1' tall. A pump mechanism of white oak lies on the ground next to the collecting tank. It is 15' 6-1/4" long and octagonal with decorative moldings carved on the upper third of the pump. Some parts of the inner workings may still be inside the pump but the suction pipe which fits into the bottom of the pump and the pump handle have disappeared.

The three leaching vats are nearly square and are framed of white oak and have side walls of tongue and groove planking. The vats vary in size. Vat #2, for example, is 11' 3-1/2" x 11' 4-1/2" and is 3' 2" tall, while Vat #1 is 10' x 8' 11". The vats sit on dry rubble stone foundations which run perpendicular to the front of the vats. Because of the dirt surrounding the vats, the height of the foundations can not easily be determined. The floor of the vats is comprised of two layers of shingle boards which rest on saplings lying

parallel to the front of the vats. The saplings rest on the vat channel drains, which resemble a tile roof. In vat #2, these drains are made of two layers of hollowed out logs. In Vat #1, the lower layer is constructed of concave carved out thick planks. The drainage system in vat #3 is obscured by the leached out soil which is piled up around all the vats. Water collecting troughs of hollowed-out tulip poplar log sit in front of each vat. All three vats are still all or partially filled with their last charge of nitrate bearing soil and all have some damage. The floor has collapsed in Vat #3, the front and one side wall is missing from Vat #2, and planks are missing from the front wall of Vat #1. Much of the wood which makes up the saltpeter works has some degree of dry rot.

A modern stone retaining wall holds back the earth from the leaching vat complex and a metal rail surrounds it to restrict access by visitors. Fluorescent lighting has been installed in the cave and some light fixtures are located in the leaching vat complex area. The visitor trail has been cut down from the mounds of lixiviated soil which surround the leaching station. More undisturbed soil mounds are located near the cave walls, as well as various pipes and other wooden fragments of the saltpeter works, including some notched log troughs which may be the remains of an earlier "v-vat" leaching system and some hand-hewn beams which may be part of a structure from the entrance area.<sup>4</sup>

The cave branches in two directions from the Rotunda and the saltpeter works continue along the easterly avenue, Broadway. Along Broadway, the park staff has laid out sections of the wooden water pipes next to the tourist trail. Also along Broadway are walls of floor breakdown stone which were built by the saltpeter workers as they moved the stone to gain access to the dirt underneath. Across from the Methodist Church, a small room off Broadway, the water pipe system exists in its original configuration with two ranks of pipes, supported by forked posts and rock cairns.

The second leaching station is located in Booth's Amphitheatre, 950 feet from the Rotunda, just below the entrance to Gothic Avenue, another large passageway which branches north above the floor level. A wooden stairway leads up to Gothic Avenue from within the leaching vat area. As in the Rotunda, the vats are lower than the present visitor trail which is cut out of discarded soil from the saltpeter operations.

At Booth's Amphitheatre are the remnants of six leaching vats and one water collection tank arranged in a row. The vats at Booth's Amphitheatre have substantial design differences from the vats in the Rotunda. Like the vats in the Rotunda they are framed of white oak and have side walls of tongue and groove planking. They have drainage floors of two layers of shingle boards which rest on saplings. However, instead of channel drains, these vats have floors of tongue and groove planking. The vats sit on stringers which rest on dry rubble stone foundations. The leach water collected between the shingle boards and the tongue and groove flooring was drained from the vats through

two small, inverted V-shaped drain outlets located on the front of the vats. These outlets could be shut off by means of a stopper which was enclosed in a casing attached to the inside of the front wall of the vat. All of the stoppers are missing. Like the Rotunda vats, all of the vats in Booth's Amphitheatre vary slightly in size. For example, Vat #2 is 12' 11-3/4" x 12' 9-1/4" and is 3' 4" high and sits on foundation walls 4' tall. The foundations for a seventh vat, Vat #5, which has been dismantled, are below the surface at the foot of the wooden stairway, which leads to Gothic Avenue. Although the height of the foundations for the Rotunda vats can not be determined accurately, they do not appear to be nearly as high as the foundations for the Booth's Amphitheatre vat system. Perhaps the foundations at Booth's Amphitheatre needed to be taller in order to allow for good drainage from the vat troughs into the collection tank. All of these vats have sustained some damage, especially collapsed floors and varying degrees of dry rot. The walls of Vat #6 are nearly all gone.

Hollowed-out logs are used as troughs in front of each vat to catch the draining leach water. The foundations, both in the Rotunda and Booth's Amphitheatre, slope slightly forward to allow the leach water to drain into the troughs. The collecting tank here was larger than the one in the Rotunda and, since nearly all of its wooden parts are missing, the primary evidence which remains today are casts made in the dirt which was piled up around it. The collecting tank had outside dimensions of 12' 3" x 9' 1" and was 2' 6" deep. The bottoms of the pump tower posts remain in place surrounding the collecting tank and the remaining parts of the four posts have been used to construct a railing along the tourist trail. As in the Rotunda, piping and mounds of lixiviated soil are evident in the area.

In addition to these major components of the saltpeter works, mining sites have been documented in some areas of the cave.<sup>5</sup> These mining sites can be identified by rock stacked walls or pits made by rock sorting. A few mattock marks made by the miners' tools, remain in the Methodist Church area and in the Gothic Avenue extension, sometimes called Backslider's Alley. Wheel hub marks, and at least one ox hoof print, remain from the ox carts which carried the earth to the vat stations.

#### Saltpeter and Gunpowder

Saltpeter is potassium nitrate ( $\text{KNO}_3$ ). It is a raw material of black gunpowder, making up about 75% of the powder along with sulphur and charcoal in roughly equal proportions. Although gunpowder was its major use, saltpeter was also used as a meat preservative. Because of its importance in the manufacture of gunpowder, saltpeter, sometimes referred to as nitre, was a necessity for both military and domestic purposes. Since the sixteenth century, most of the world's supply of saltpeter had come from India, where natural supplies of nitrates could be found in dry areas, and its price in Calcutta had determined the price of gunpowder around the world. However, Great Britain controlled Indian saltpeter, and during the Revolutionary War

and again during the War of 1812, American supplies were cut off. In addition, isolated frontiersmen could not always count on supplies of commercial gunpowder and saltpeter, and had to make their own. During the American Revolution, one of the primary sources of saltpeter was from artificial niteries, "maloderant holes in which weeds, animal and vegetable refuse, and the sweepings of slaughterhouses were mixed with limestone, old mortar and ashes and wetted down with urine". The saltpeter "farmers" were frequently the same men who cleaned privies.<sup>6</sup> The Continental Congress, as well as several state governments, published instructions on the making of saltpeter and strongly encouraged the industry. This method was widely used in Europe, and Denis Diderot's Encyclopedia of 1790 included extensive instructions on the making of saltpeter from compost.<sup>7</sup> It took about 100 pounds of compost to make one-quarter to one-half pound of saltpeter.

Artificial niteries were not the only source of nitrates in America. The earth of some caves was found to contain nitrates in the form of nitrocalcite, in which the nitrates are bonded to calcium. However, such cave saltpeter absorbs moisture from the air, which makes it inappropriate for use in gunpowder which has to be dry to work properly. But the cave saltpeter could be processed with wood ashes, high in potassium, into potassium nitrate which does not absorb moisture. This form of saltpeter could be used to make gunpowder.

Early researchers felt that the nitrate content of cave soil was the result of decomposing bat guano in the caves, but early in the 20th century, it was suggested that the nitrates come from surface soil nitrates leaching into the cave through groundwater. The fact that nitrate-saturated earth is only found in dry areas of caves seemed to conflict with this hypothesis, but Carol Hill, an authority on saltpeter making, believes that the water carrying the nitrates seeps into the cave by capillary action, rather than drip or flow. Nitrifying bacteria within the cave act on this reduced form of nitrogen and produce nitrates. A limestone cave with a forest on the surface provides the best opportunity for nitrates to form in the cave soil. This theory accounts for several factors observed by the early saltpeter processors: the ability of the soil to regenerate nitrates after a relatively short period of time (perhaps about three years) and the depth of penetration of the chemicals in the soil. The best saltpeter earth is near the top, rather than consistent at all depths, as would be the case if it was composed largely of built-up bat guano. Nitrates also are found in the cave bedrock, where they would not be found if the nitrates were the result of bat guano. Because nitrocalcite dissolves easily in the presence of water, it is only found in dry areas of caves, without a constant water drip like that which forms stalactites and stalagmites.<sup>8</sup> The historic area of Mammoth Cave meets this qualification. This nitrate-saturated earth was found in limestone caves in Virginia and, as the pioneers moved west, in the caves of Indiana, Alabama, Tennessee, and Kentucky.

## Kentucky Saltpeter Industry

Saltpeter processing was an important early Kentucky industry. By 1806, at least twenty-eight saltpeter caves had been discovered and put into production.<sup>9</sup> Conditions, both geographical and geological, had to be right for a cave to be suitable as a commercial saltpeter cave. First, there had to be enough nitrates in the subsoil to justify mining; and then there had to be an adequate water supply, preferably inside the cave, for processing the cave earth. There also had to be a nearby forest for wood ashes to process the saltpeter and to fire the furnaces for processing potassium nitrate. Finally, there had to be adequate transportation nearby to bring the saltpeter to market. Present evidence indicates that of the 3,770 known Kentucky caves, about 180 Kentucky caves and rockshelters were mined for saltpeter. The Cumberland Plateau in eastern Kentucky has the largest number of identified saltpeter and gunpowder sites. The Mississippian Plateau, where Mammoth Cave is located, has the second largest number of sites. Undoubtedly many of these were mined just to service local needs.<sup>10</sup> In 1810, 201,937 pounds of saltpeter with a value of \$33,648 were processed in Kentucky. This probably does not include small amounts processed for personal or local use and not reported to the Bureau of the Census.<sup>11</sup> The United States Government's trade restrictions which preceded the War of 1812 led to increased interest in Kentucky's saltpeter caves.

## The War of 1812

The War of 1812 came about as a result of the Napoleonic Wars in Europe. Both England and France infringed upon the right of neutrals to engage in free trade, although eventually France agreed not to interfere with American trade with Britain. Britain, however, wanted all American ships bound for France to stop in England first to pay duties; Britain also impressed American seamen into the British navy. From 1806 until the declaration of war in 1812, the United States reacted to this situation with various trade restrictions such as non-importation acts, passed in 1806 and 1811; an embargo against all American ships leaving port in 1807; and non-intercourse acts barring trade with England and France in 1809. None of these actions forced Britain to call off its blockade, and so in 1812, the United States declared war.<sup>12</sup> The United States was unprepared for the war in many ways and one major difficulty was the shortage of saltpeter for gunpowder.

As in the Revolutionary War, imports of saltpeter from British-controlled India were cut off. Various people had been investigating the issue of saltpeter supply for several years. In 1806, Dr. Samuel Brown, a professor at Transylvania University medical school in Lexington, Kentucky, prepared a paper for the American Philosophical Society discussing the importance of cave saltpeter to the United States in time of war. Brown's interest in saltpeter was not solely a matter of national defense since he owned the Great [Saltpeter] Cave on Crooked Creek, in Madison (now Rockcastle) County, Kentucky, a cave which rivaled Mammoth Cave in the amount of saltpeter

produced during the War of 1812.<sup>13</sup> Also in 1806, the Medical Repository, which despite its name served as a general scientific journal, also discussed the usefulness of cave saltpeter in time of war.<sup>14</sup> In 1811, Eleuthere Irene du Pont, owner of E.I. du Pont de Nemours and Company, a gunpowder mill in Delaware, warned President Madison of the difficulty of securing saltpeter if war with England cut off Indian imports. On his advice, the U.S. Government purchased \$50,000 worth of Indian saltpeter at 16 to 20 cents per pound.<sup>15</sup>

Even this major purchase did not fully supply American needs. As the price of saltpeter increased, the profits of manufacturing saltpeter also increased. This sudden demand "set half the Western world gadding after nitre caves -- the gold mines of their day. Cave hunting became a kind of mania, beginning with speculators, and ending with hair-brained young men, who dared from the love of adventure the risks that others ran for profit."<sup>16</sup> Although caves had long been a source of saltpeter for local needs on the frontier, suddenly they were extremely valuable commercial properties.

#### Mammoth Cave as a Saltpeter Source

Mammoth Cave had been identified as a saltpeter cave as early as 1799. Valentine Simons, who in 1797 had filed for a patent on 200 acres of land south of the Green River, had the land surveyed in 1799. The survey noted two saltpeter caves on the tract. Sometime later, Simons sold the tract and the two caves to John Flatt for \$116.67, a figure which suggests that the money noted may not have been the entire purchase price. Flatt may have mined and processed saltpeter in a small way. Probably before January 22, 1808, John Flatt sold his land and caves, the larger cave by then known as Flatt's Cave, to George, Leonard, and John McClean (or McLean) for \$400.<sup>17</sup> Little is known of Valentine Simons, John Flatt, or the McClean brothers. It is likely that their mining of Mammoth Cave for saltpeter was carried out on a limited scale and the results of their labors sold to local powder mills for use on the Kentucky frontier or to a wholesale buyer of saltpeter.

The McCleans, however, must have done enough exploring, mining, and processing to realize the great potential of the cave, for by January 1810, when they sold the cave to Fleming Gatewood and Charles Wilkins, the purchase price had increased to \$3,000 for 156 acres of property and the caves.<sup>18</sup> The embargo on imports from Great Britain and the threat of war made a saltpeter cave a very attractive business proposition and Mammoth Cave met all of the requirements for a successful saltpeter cave. The cave's miles of dry passages provided vast quantities of earth to mine and the waterfall at the mouth of the cave could be captured for processing the saltpeter. Forests along the nearby Green River supplied wood for furnaces and processing. Most importantly, the cave was located near a major transportation route, the main road between Nashville, Tennessee and Louisville, Kentucky. From Louisville, saltpeter could be shipped east via Pittsburgh, or on flatboats to New Orleans and then by ship to the eastern United States.

Mammoth Cave was not the only cave in the area to be exploited for saltpeter. In April 1810, Alexander Wilson noted that glauber salts were found in area caves "but the principal production is saltpeter, which is procured from the earth in great abundance."<sup>19</sup> The Cave Research Foundation has located at least twelve other caves in the Mammoth Cave vicinity which were mined for saltpeter. In 1814, the owners of another Warren County cave, purchased primarily for its saltpeter content, sued the men who sold the cave to them accusing them of pouring saltpeter water over the cave soil so that it would test strongly of nitrates and of making false claims about their yearly production.<sup>20</sup> The craze for saltpeter caves was so strong in the Mammoth Cave area that thirty years later one local man remarked that "every hole the size of a man's body has been penetrated for miles around the Mammoth Cave."<sup>21</sup>

The purchase of the cave by Charles Wilkins and Fleming Gatewood signaled a major change in the way operations were carried on at Mammoth Cave. Unlike the cave's previous owners, Charles Wilkins was not a frontier farmer attempting to eke out a living by mining saltpeter. He was a member of the highest level of Lexington society, a merchant with important family and business connections. His partner, Fleming Gatewood, was born in Virginia and moved to Louisville, Kentucky, with his family in the 1790s. Although not as well connected as Wilkins, he must have had some financial resources since he purchased about 900 acres of land in the Mammoth Cave area in the years 1808 to 1810. Unlike Wilkins, Gatewood lived in the Mammoth Cave area. His brothers also may have been involved in the saltpeter processing operation.<sup>22</sup>

Charles Wilkins was born in Pennsylvania about 1763, the son of John and Catherine Wilkins. John Wilkins was a merchant in Lancaster, Pennsylvania and moved to Carlisle, Pennsylvania about the time of his son's birth. John Wilkins served as a captain in the Continental Army and in 1783 moved to Pittsburgh where he engaged in trade with the west. Two of Charles Wilkins' brothers held important government positions. John Wilkins Jr. was quartermaster general for the western states during the War of 1812 and became actively involved in Charles Wilkins' saltpeter business. Their younger brother, William, held a military position during the War of 1812 and later became president of the Bank of Pittsburgh. In public life he served as a judge, U.S. senator, minister to Russia, and Secretary of War under President Polk.<sup>23</sup>

Charles Wilkins moved to Lexington, Kentucky by the early 1790s and established himself as a merchant with a variety of business interests. He became president of the Lexington branch of the Bank of Kentucky in 1808. He also was a partner in a firm in Natchez, Mississippi; owned a rope walk in Lexington (for making rope from the area hemp crop); was one of the lessees of the United States Saline Works in Illinois; and owned a farm in Woodford County, outside of Lexington. After the War of 1812 he was a partner in the Aetna Iron Works, one of the first iron furnaces in Kentucky.<sup>24</sup> During this time, Lexington was at its peak as a commercial center and much of western trade occurred in Lexington.<sup>25</sup>

Wilkins became actively involved in Lexington society serving as trustee of Kentucky University, acting as incorporator of the Kentucky Mutual Assurance Company (a fire insurance company), and serving as trustee of the Second Presbyterian Church.<sup>26</sup> He was apparently well acquainted with Lexington's leading citizen, Henry Clay, who described Wilkins as a "decided and thorough going federalist,... a respectable and highly honorable man."<sup>27</sup> Charles Wilkins married Jane Short, sister of another Lexington merchant, Peyton Short. Another of her brothers, William Short, served as minister to France under Jefferson and her sister was married to Dr. Frederick Ridgely, professor of medicine at Transylvania University.<sup>28</sup>

From at least 1808, Charles Wilkins was a wholesaler of saltpeter purchased from small producers throughout Kentucky. Wilkins may have also had some business association with Dr. Samuel Brown, operator of Great Saltpeter Cave, the largest saltpeter operation in that part of the state. Certainly Wilkins and Brown knew each other since Wilkins' brother-in-law, Dr. Ridgely, was Dr. Brown's colleague at the Transylvania University medical school. The extent of their business relationship has not been thoroughly investigated, but could shed light on Wilkins' saltpeter business and on operations at Mammoth Cave. It seems unlikely that Wilkins had an interest of some sort in Great Saltpeter Cave.<sup>29</sup> Charles Wilkins sold saltpeter to eastern gunpowder manufacturers and one important customer was Archibald McCall, the agent for E.I. du Pont de Nemours and Company. Wilkins' suppliers used very crude processing methods and some of the saltpeter he purchased was highly contaminated. Wilkins and duPont corresponded about the quality of the saltpeter Wilkins' provided. Wilkins did not apologize for the quality but simply stated the fact that "others were always ready to receive it, if it had been rejected by me." He also noted that he tried to guard against sand and gravel being mixed in but could not avoid impure saltpeter by avoiding certain dealers, since his sources had "been so numerous, & generally living in caves and mountains on our frontier that I should have no knowledge of them again..."<sup>30</sup> Perhaps Charles Wilkins purchased saltpeter from the McCleans at Mammoth Cave and learned of the potential of their cave in that way.

At any rate, Charles Wilkins decided to move from being a middleman to being a saltpeter producer by buying Mammoth Cave in January 1810. He and his partner, Fleming Gatewood, operated the Mammoth Cave Saltpeter Works until April 1812, with Gatewood probably acting as resident manager at least part of that time.<sup>31</sup> In 1812, Gatewood sold his half interest in the Mammoth Cave saltpeter works to a Philadelphia merchant, Hyman Gratz.

Gratz was born in 1776, in Lancaster, Pennsylvania, the son of Michael and Miriam Simon Gratz. Michael Gratz and his brother, Bernard, were traders and merchants and invested in western lands. In 1798, when Michael Gratz retired, Hyman Gratz and his brother, Simon, reorganized the firm as Simon and Hyman Gratz, later Simon Gratz and Company. The company moved to Philadelphia where they outfitted sailing ships, invested in insurance and canals, and managed

Michael Gratz' western land holdings. They were patrons of the arts and entertained authors and painters such as Washington Irving and Thomas Sully.<sup>32</sup>

The business relationship between Charles Wilkins and Hyman Gratz undoubtedly predated their involvement in the Mammoth Cave Saltpeter Works and probably went back to the 1760s when Michael Gratz, the father of Hyman Gratz, and John Wilkins, the father of Charles Wilkins were both merchants in Lancaster, Pennsylvania. Hyman Gratz may have invested in some of Charles Wilkins' Kentucky enterprises, and he also had some involvement in the U.S. Saline Company in Illinois. Simon Gratz & Company had many dealings with Henry Clay over the estate of Wilkins' former partner at the U. S. Saline Company, Col. James Morrison. Charles Wilkins' brother, William, who lived in Pittsburgh, corresponded with Hyman and Simon Gratz regarding their father's land investments.<sup>33</sup> After the war, Hyman Gratz' younger brother Benjamin moved to Lexington and became a merchant and one of the city's leading citizens. Although Hyman Gratz did not formally purchase interest in the Mammoth Cave properties until 1812, he may have had some interest in the business beforehand as some part of his general business relationship with Charles Wilkins. At any rate, the departure of Fleming Gatewood and the addition of Hyman Gratz to the Mammoth Cave operation was probably not sudden. Gratz and Wilkins eventually owned more than the 144 acres immediately surrounding Mammoth Cave. They acquired Dixon's Cave, also used for saltpeter production in 1813 and, by 1815, owned 1490 acres of land in Warren County, Kentucky. They may have produced saltpeter at several caves. Wilkins' brother-in-law, Peyton Short, owned Short Cave, several miles south of Mammoth Cave.

#### Gunpowder Production During the War of 1812

During the war, Wilkins and his associates sold saltpeter to E.I. du Pont de Nemours and Company, through du Pont's Philadelphia agent, Archibald McCall. E. I. du Pont had been trained in France under the renowned French chemist, Antoine Lavoisier and came to the United States with his family after the French Revolution. In the fall of 1800, he decided to build a powder mill, as there were only three such mills in the country at that time and du Pont thought their products quite inferior. After searching for a suitable location, he purchased land on the Brandywine Creek in Delaware and began construction of his mills. He refined his first saltpeter, the first step in gunpowder making, in 1804 and began manufacturing black powder soon after. In the company's earlier years, du Pont sold little to the United States Government, despite the fact that his father and President Jefferson were personally acquainted. Other powder makers seemed to have greater personal influence with Congress and the War Department. However, by the time war was declared in 1812, du Pont's superior product had attracted a larger percentage of the government's business.<sup>34</sup>

The process of making gunpowder was quite simple, but dangerous, since the material could explode even with the most careful handling. A typical powder mill of the early nineteenth century included a saltpeter refinery since purer saltpeter made better gunpowder. The crude saltpeter purchased from India or from American caves was contaminated with other minerals. The powder mill equipment included wheel mills for grinding the raw materials of saltpeter, sulphur, and charcoal (apparently du Pont preferred charcoal of willow wood). Bolters sifted each of the components separately. The saltpeter, charcoal, and sulphur were given a preliminary mixing, and ground together in a stamping mill which operated similarly to a mortar and pestle. The next step was graining where the powder was sieved into different sizes. In the final glazing, the powder was perfected. It was then packed and shipped.<sup>35</sup>

During the War of 1812, du Pont sold at least 750,000 pounds of black powder to the U.S. Government, as well as additional amounts to others.<sup>36</sup> This would have required about 570,000 pounds of saltpeter, far more than the approximately 275,000 pounds purchased by the government at du Pont's urging before the war. Most of the additional saltpeter presumably came from cave saltpeter. Du Pont's agent in Philadelphia purchased saltpeter from many sources including Charles Wilkins. According to du Pont company records, the highest price the company paid for saltpeter during the war was about 38 cents per pound, about twice what had been paid before the war. Although Wilkins sold a great deal of saltpeter to du Pont, he also sold saltpeter from his own cave and that which he had purchased from others, to other manufacturers. Wilkins incurred du Pont's wrath in early 1814 by refusing to honor his contract because he had agreed to ship all the saltpeter from his own cave to his partner Gratz. Du Pont ended the business relationship with Wilkins which had been in effect since about 1808.<sup>37</sup>

#### Construction of the Mammoth Cave Saltpeter Works

There is no precise evidence regarding when the saltpeter works at Mammoth Cave were constructed. Saltpeter was being made by January 21, 1810, but probably utilized an earlier V-vat system. An anonymous letter writer noted on that date that "the workmen are supplied with a sufficiency of water for their saltpeter works" from the waterfall at the mouth of the cave. The writer also mentioned that furnaces were being constructed on the surface.<sup>38</sup> What scale of production would require furnaces? It seems likely that a very small scale operation would simply use open fires. This letter was written just at the time that Gatewood and Wilkins bought Mammoth Cave and the price they paid implies that a fair amount of activity was already going on at the cave.

One of the earliest maps of Mammoth Cave is the map known as the "eye draught" map. Although this map can not be precisely dated, Dr. Benjamin Rush, the Philadelphia physician and signer of the Declaration of Independence who had written much of the saltpeter instructions for the Continental Congress, received a copy from Dr. Frederick Ridgely, Charles Wilkins' brother-in-law

prior to March 15, 1811. This map shows leaching vats in place near the mouth of the cave and describes the quality of the saltpeter earth in the cave. "It has been explored about 7 miles from the termination of the narrows. The clay impregnated with nitre has been found to be generally about 5 ft. deep, extending quite across the cave....The clay in the principal cave produces six lbs. of saltpeter to every bushel [of earth]." The map also shows areas of the cave rich in saltpeter.<sup>39</sup> The vats shown on the map were probably V-type vats used by the McCleans in their processing operations and possibly in the early months of the Gatewood-Wilkins partnership.

By June 8, 1811, Charles Wilkins had contacted du Pont's agent, Archibald McCall, about purchasing superior saltpeter from Wilkins' own cave. McCall was instructed by du Pont to tell Wilkins to "be particular in having all his casks branded G & W" so that the saltpeter from Wilkins' cave could be identified and tested.<sup>40</sup> Another copy of the "eye draught" map sent to E. I. du Pont before June 11, 1811, indicates that plans were being made to "convey water and erect leeches[sic]" in the big room of the cave, the room today known as the Rotunda.<sup>41</sup> By late October 1811, contracts had been completed for saltpeter from Wilkins' cave and du Pont had arranged to purchase 10,000 pounds per month through the following May. The saltpeter would be shipped to Pittsburgh where Charles Wilkins' brother, General John Wilkins, would forward it on to du Pont.<sup>42</sup>

The vats in Booth's Amphitheatre, which have substantial design differences from the vats in the Rotunda, were probably constructed after the vats in the Rotunda, although it is difficult to estimate how much later.<sup>43</sup>

A letter to du Pont from his agent, McCall, in Philadelphia, dated December 30, 1912, indicated that the cave had produced little saltpeter in the recent months because of repairs to the works.<sup>44</sup> However, the saltpeter works could not have been completely shut down because Gratz and Wilkins had recently sold 100,000 pounds of saltpeter to someone else, "the most part of which was coming from their own cave."<sup>45</sup> These repairs may have consisted of additional construction, modifications, or simple repairs.

Little is known about the design of the saltpeter works at Mammoth Cave, especially the vat system. Nearly all other saltpeter operations in this country used crude hoppers, rectangular in plan, that tapered to a "V" at the bottom. There apparently were no technical manuals or reports written which describe box hoppers, so there is no contemporary theoretical work to compare to the Mammoth Cave works.<sup>46</sup> The Civil War-era instructions written for the Confederate Nitre and Mining Bureau describe V-vats and only mention box hoppers like those at Mammoth Cave. Researchers, looking at caves near Mammoth Cave for remains of saltpeter operations, believed that several nearby caves may have had square vats, but other more recent investigations have questioned these findings.<sup>47</sup> Possibly only the operations at Great Saltpeter Cave used this same type of square vat. Angelo George, another contemporary authority on saltpeter, believes there is a possibility that

John James Dufour, a wine maker, assisted Samuel Brown and Thomas Hart, Jr., the original operators of Great Saltpeter Cave with the establishment of their saltpeter works and that the design of these vats may be related to wine press vats.<sup>48</sup>

#### Operation of the Saltpeter Works

Hyman Gratz and Charles Wilkins apparently spent little time at Mammoth Cave during the years of the saltpeter operations. Gratz did come to the cave at the time he purchased Fleming Gatewood's interest, and his name is written in the cave. Wilkins later said that others could describe the cave better than he, as he had spent little time there.<sup>49</sup> Fleming Gatewood may originally have served as resident manager, but he was apparently replaced early on by Archibald Miller and his brothers, James and Robert. The Millers were born in Ireland and came to Kentucky from Pennsylvania. Why they came to the cave area and what had been their previous experience with saltpeter is unknown. Many years after saltpeter production ended, Franklin Gorin, a later owner of the cave, reported that Robert had been a merchant in Philadelphia and had been ruined financially in the Aaron Burr conspiracy.<sup>50</sup> The Philadelphia connection suggests that the Millers were known by Hyman Gratz. The Aaron Burr connection suggests a relationship with Charles Wilkins, since several of Wilkins' Lexington acquaintances had some involvement with that conspiracy, including the owner of Great Saltpeter Cave, Dr. Samuel Brown.<sup>51</sup> Possibly the Millers just drifted to Kentucky for other reasons and went to work for Wilkins after gaining experience in other saltpeter caves. James and Robert Miller first appear on Barren County, Kentucky tax roles in 1805 and 1808 respectively. The younger Archibald was first listed in 1811 when he was twenty-six years old.<sup>52</sup>

The only other identified person involved in the saltpeter processing at Mammoth Cave was a man identified in the 1840s as "old man Holten."<sup>53</sup> This was probably John Holten who lived in Warren County and whose name has been found written in the cave. Holten may have been a foreman of the operation inside the cave. The majority of laborers in the saltpeter works were probably slaves. Undoubtedly the number of workers fluctuated during the operation. Fleming Gatewood, who was most familiar with the operation in its earliest years, said in 1814 that the amount of saltpeter in the cave could "keep 10 men busy for 10 years."<sup>54</sup> Ebenezer Meriam, who supplied the works with wood ash, writing of 1814, said that there were 70 slaves working in the cave.<sup>55</sup> John Farnham, of the American Antiquarian Society and who probably only knew about the works at the end of their operation, claimed the workers numbered 20 or 30.<sup>56</sup> It is not known who owned these slave laborers. However, it is known that Samuel Brown, at Great Saltpeter Cave, advertised to hire slaves on contract from their owners. Perhaps Wilkins and his associates used the same system.<sup>57</sup>

The first step in producing saltpeter was to locate likely mining sites. There were several tests used to locate caves which might produce saltpeter. First the cave had to be dry with no dripping water near the potential mining sites. Sometimes whitish, needle like crystals of saltpeter could be seen in partially buried rocks.<sup>58</sup> Even if no crystals could be seen, a taste of the the dirt might indicate saltpeter if it had a salty-bitter, cool taste. However, this was an inconclusive test, as epsom salts had a similar taste. Stirring up the cave dirt and leaving it alone for two to five days might show saltpeter if the dirt smoothed itself out. The best test was to process a small amount of dirt. The prospector could then taste the crystals, throw some into a fire (saltpeter sparkles and flames), and soak a paper with a solution of the crystals (the dried paper would burn with a clean fast glow). Finally, a small amount of gunpowder could be made and fired.<sup>59</sup>

Duane DePaepe and members of the Cave Research Foundation recently conducted a survey of Mammoth Cave to locate sites which were mined for saltpeter. Most of the sites were fairly near the leaching stations, for convenience in transporting the heavy cave dirt to them. Some mining sites were: Houchins Narrows, the main entry passage into the cave; Audubon and Little Bat Avenues, the westerly branches from the Rotunda area; Broadway, the large passageway between the two leaching stations; Methodist Church, a short passage off of Broadway; Gothic Avenue; a long passage located above the Booth's Amphitheatre leaching station; and several passages farther from the leaching stations, including Cyclops Gateway, Harvey's Avenue, Gratz Avenue, and Salts Avenue. A remote area, Blue Spring Branch, was apparently mined to some extent, but this may have only been a prospecting venture trying to locate additional likely mining areas. Stacked rock walls, built by the miners moving floor breakdown rock to reach the earth beneath, are the primary physical evidence of mining in the cave and can be seen today along Broadway, Cyclops Gateway, and Audubon Avenue. The miners used wooden pry bars to help move the rock. Mattock marks, made in the dirt by the miners' tools used to break up dirt, were discovered in Gothic Avenue extension (also known as Backslider's Alley), opposite the Booth's Amphitheatre leaching station and in Methodist Church.<sup>60</sup>

The miners used small wooden paddles to scrap dirt off of rocks or to pick up dirt loosened by their mattocks. They probably filled small wooden boxes or cloth bags with the aid of these paddles and then carried these small loads from the narrower passages out to the main areas of the cave. After reaching the main passages, the miners dumped their dirt into an ox cart which was utilized in the cave to transport loads. This ox cart must have greatly sped up the transportation of the heavy dirt to the leaching hoppers. The ox cart route has been described as a "wagon road" or a "turnpike" road leading recent researchers to conclude that it looked much like today's compacted visitor trail. However, roads in the early 19th century rarely were that good and the ox cart route was probably just passable and free of very large rocks. The oxen were stabled in the cave in an area beyond Booth's Amphitheatre because it would have been difficult to move them in and out of the cave due to the steep grade at the entrance. Remains of corn cobs could be seen in the stabling area beyond Booth's Amphitheatre throughout the 19th century.<sup>61</sup>

Oxen hauled the cartloads of dirt to the two leaching vat complexes and the laborers shoveled the earth into the vats. Water, which was fed into the cave by gravity through a log pipeline, was fed into the vat from a pipe which ran along the top of the vat. This water entered the pipeline at the entrance where it had been collected in a trough from the entrance waterfall. Valves, or plugged holes, in the pipe were unplugged and the water flowed into the vat. The ability to pipe water far into the cave saved moving the heavy cave dirt long distances and made the operation proceed faster and more economically.

Because of differences in vat construction, the processing of the dirt differed somewhat at the two leaching stations. At the Rotunda, some water probably began to immediately drain out of the vat, because there was no simple way to plug the channel drains used there. However, because of the amount and density of the dirt in the vat enough water would remain to thoroughly mix with the earth to form a mud of a smooth consistency. Chunks of unwetted dirt could not release saltpeter so all of the dirt had to be broken up and mixed. The laborers probably mixed the earth and water with paddles or even by walking around in it.<sup>62</sup> As water drained from the vat, more water was added until it was felt that all of the chemical had been removed from the earth. Civil War era technical manuals frequently called for a layer of twigs, reeds, or straw at the bottom of the vat to help strain mud from the leach water, but there is no evidence of this in the dirt or vats in Mammoth Cave.<sup>63</sup>

After draining into a trough in front of the vat, the water was collected into the collecting tank under the pump. A direct connection between the vat trough and the collecting tank can only be seen at vat #3 where a piece of hollowed out log allows the water from that vat to drain directly into the collecting tank. Since earth completely covers the drains in Vat #3, short of archaeological investigation, there is no way to determine exactly how the drains from this vat work. Water from Vat #1 probably flowed into the trough in front of Vat #2, and then flowed through a pipe or drain to the collecting tank. Because there was apparently an efficient system of water transport, it does not appear that water was re-leached through the vats to become more saturated with chemicals as was recommended by some saltpeter technical manuals.

At Booth's Amphitheatre, the vat system operated somewhat differently. Like the Rotunda vats, the vats in Booth's Ampitheatre were filled with earth and fresh water flowed by gravity from the entrance as it had to the Rotunda. However, the vats at Booth's Amphitheatre had only two small drain holes in the front of each vat, which could be plugged up by means of a stopper which fit into a casing attached to the inside front wall of the vat. The water could stand for extended periods of time in the vats in Booth's Amphitheatre, thoroughly mix with the mud, and leach more of the nitrates out of the soil. After standing for a sufficient period of time, the drain holes could be unplugged and the water would drain into the troughs in front of the vats. As in the Rotunda it appears that the leach water flowed from trough to trough

and then directly to the collecting tank. The troughs in Booth's Amphitheatre have small holes in their ends which were probably connected by pipe to the adjacent trough. After being leached, the used-up dirt was shoveled from the vats and piled at any available site in the cave. The great amount of dirt used in the processing can be seen in the height of the visitor trail which is cut down from these piles of soil and in the undisturbed mounds nearer the cave walls.

The leach water collected in the tank at Booth's was pumped up and then flowed by gravity to the collecting tank in the Rotunda where it was again pumped up and flowed by gravity to the cave entrance (see illustration of the Booth's Amphitheatre pump tower). At the cave entrance, the water was lifted to the surface. Although in simplified form, this is how the process worked. Many parts of the pumps, pump towers, and pipeline are missing today, and written evidence is limited. Only conjecture can be made about the details of the operation. In order for the water from Booth's Amphitheatre to flow by gravity to the Rotunda, it would have to be lifted by pump about 18 feet above the bottom of the collecting tank.<sup>64</sup> Timbers which form the hand rail along the visitor trail above the vats are assumed to be members of the Booth's Amphitheatre pump tower. Since these timbers average twenty feet long they support the concept of a pumptower of sufficient height to provide for gravity flow. A simple suction pump, like the pump body which remains in the Rotunda, could have accomplished this. A suction pump lifts water by a piston creating lower pressure inside the pump body than the outside air. This forces water up into the suction pipe. Eventually it is trapped in the pump by an intake valve and as the pump body becomes full of water, the water flows out the outlet hole. A tradition of cave guides says that there were holding tanks on top of the pumptowers.<sup>65</sup> Later researchers have believed that the pipeline was connected directly to the pump and that each successive spurt of water just flowed on to the next collecting tank.<sup>66</sup> However, because the collecting tank at the Rotunda is so much smaller than the tank at Booth's Amphitheatre, this suggests that there had to be some means of measuring or controlling the flow of water from Booth's to the Rotunda. A holding tank of similar capacity to the Rotunda tank at the Booth's pump would insure that excess water was not sent along the system.

The pumping process at the Rotunda is less evident. For the water to flow by gravity to the entrance of the cave, the water would have to be lifted about 22'6". However, the tallest post of the three remaining posts timbers is only 16' 1-3/4" tall. This would suggest that the pump handle was only about 20'6" from the floor of the collecting tank, in order for the pump handle to be at a convenient height from the tower platform for pumping. Therefore, the pump outlet hole would be only about 18 feet above the floor of the collecting tank or about four feet too low for gravity feed.<sup>67</sup> Perhaps the pumptower post has been shortened, but this does not appear to be the case. It does not appear to have been burned, which is what destroyed most of the Rotunda pumptower. Possibly the water inlet and outlet pipes are buried several feet below the gate or the entrance at the gate was lower at the time of the saltpeter operations.

The pumptower would have been 8' 9" x 8' 4-1/2" (from center post to center post), which would provide a platform for the pump operator to stand on as well as a space about 5' x 5' in front of the outlet hole which could have been for a holding tank. If the pump body which is in the Rotunda today is the same pump that was used in the saltpeter works, it presents several questions. The outlet hole of this pump has a straight bore which would not allow a tight fit for a water pipe (the pipe to pipe connections in the Mammoth Cave water system have tapered bores). The cut also appears to be clean, suggesting that nothing has ever been jammed into it and sealed as a water pipe would need to be. Because the tower appears to be too short to operate a gravity feed and the pump body does not appear to have had a direct pipe connection, it is unclear how the water system moved leach water from the Rotunda to the entrance.

At the cave entrance, the leach water was again collected and then lifted to the ground surface, approximately 45 feet. Since there are no remains of this part of the operation, we are dependent on contemporary observers and illustrations to determine how it worked. The evidence is limited. John Farnham of the American Antiquarian Society writing in 1817 said that the water was lifted from the cave in buckets.<sup>68</sup> It is not certain that he was ever at the cave, but he probably based his remarks on information from Charles Wilkins. Ebenezer Meriam, who was at the cave in 1814, but did not write about it until the 1840's, said that the leach water was pumped out.<sup>69</sup> For the water to be pumped to the surface, at least two staggered pumps with collecting tanks in between each pump would be required to make the 45 foot lift using the same kind of simple lift pump found in the Rotunda. This type of pump can only lift a column of water about 22 feet in its suction pipe, plus the length of the pump body.<sup>70</sup> A pump would be subject to freezing during the coldest winter months, halting operations if it was the only means of moving the water. Buckets may have been used during the winter. An illustration of the cave entrance, made in the 1830's, shows a beam across the entrance, supported by the rock ledges which must have been part of the entry water lifting system.<sup>71</sup> However, it does not reveal very much about the type of water lifting system used.

Above ground, chemical conversion of the cave saltpeter and crystallization were carried out. As no physical evidence of this part of the process remains, the outline of activities is based on contemporary reports, saltpeter instruction manuals, and recent historical experimentation.

The cave saltpeter had to be chemically converted to potassium nitrate. Wood ashes, either in the form of potash (potassium carbonate) or potash lye (potassium hydroxide) supplied the necessary potassium for the conversion. The process may have been done in several ways, any one as chemically efficient as the other.<sup>72</sup> The saltpeter brine from the cave could have been heated in kettles and the wood ashes mixed in. A gelatinous precipitate of calcium hydroxide would form and have to be skimmed or strained out along with the ash residue. The remaining liquid would be potassium nitrate in solution.

Another method which could have been used required leaching hot, fresh water through vats of wood ashes. The resulting lye, potassium hydroxide, was then mixed with the leachwater from the cave. This also formed calcium hydroxide as a precipitate which was skimmed or strained out as in the first method. In a third possible method, the leachwater from the cave was heated and leached directly through vats of ashes. This also resulted in the precipitate of calcium hydroxide and the potassium nitrate in solution. This last method required the least number of steps and is likely the one used.<sup>73</sup> "To make 100 pounds of good saltpeter at the great cave, eighteen bushels of oak ashes are necessary; ten of elm, or two of ashes made by burning the dry wood in hollow trees."<sup>74</sup> The saltpeter workers were careful to balance the proportions of leachwater to ashes.

Although there is no evidence of what was done with these precipitates, something must have been done with them since there is no visible evidence today at the cave entrance of what must have been a lot of waste material. The only written evidence is a mention of "calcining and evaporating furnaces" made by Ebenezer Meriam.<sup>75</sup> Calcination is a powdering process and perhaps the calcium hydroxide was turned into powder. In that form, it is an ingredient of plaster and mortar and could have been sold to add to the revenues of the operation.

After chemical conversion, the potassium nitrate solution was then crystallized. This was done in iron kettles over fires built in stone furnaces located on the right rim of the cave. There were at least two furnaces at Mammoth Cave, but there may have been more.<sup>76</sup> Great Saltpeter Cave had at least four furnaces, three of them located about 900 feet from the cave entrance.<sup>77</sup> The furnaces at Mammoth Cave had twenty foot chimneys which caused hotter fires and carried the smoke further from the workers. As many as fifty kettles may have been used in the operation.<sup>78</sup> In previous research, two kettles have been located which may have been used in some part of the Mammoth Cave saltpeter operation. One was a round iron kettle with a flanged edge which was a common type of crystallization kettle. The other is a large iron kettle with flattened sides made to nest next to two other kettles.<sup>79</sup> This large kettle may have been used to heat water.

Heating removed water from the solution and caused waste materials to crystallize out. Old reports called these crystals sea salt (calcium chloride), but recent experiments produced no sea salt, but crystals of arcanite and schoenite. Some sources suggest that turnip chunks were thrown in at this point to absorb dark color and oxblood, glue, or alum added to cause organic material to rise to the surface where it could be skimmed out. After the waste materials crystallized out while being heated, the concentrated potassium nitrate solution was poured into troughs to cool. As it cooled, the crystals of potassium nitrate formed. These were skimmed out and dried in the sun or over a low fire. The leftover liquid was added back to the potassium nitrate solution still at some earlier stage of processing.<sup>80</sup> All of these operations were done in open air, or possibly under open sheds, which must have slowed operations considerably in poor weather.

After being dried the crystals were packaged and shipped to eastern dealers. Although there were four powder mills in the immediate Mammoth Cave area, and many more in eastern Kentucky, Wilkins and company apparently sold all of the Mammoth Cave saltpeter to powder makers in the eastern United States, especially E.I. du Pont de Nemours and Company.

It is not known exactly how much saltpeter was made at Mammoth Cave. Most sources mention that three to five pounds of saltpeter could be made from a bushel of cave dirt.<sup>81</sup> However, Fleming Gatewood said that each bushel yielded only about 1-1/2 to 2 pounds, except in July and August, when the yield was less.<sup>82</sup> The 1810 Census reported that 22,850 pounds of saltpeter with a value of \$3,808 was produced in Warren County, the county which then encompassed Mammoth Cave.<sup>83</sup> This census covered the first year of the Wilkins-Gatewood operation and, of course, included the production from all of the many caves in Warren County. In October 1811, Charles Wilkins contracted to sell 60,000 pounds of saltpeter from his own cave to du Pont over a six month period. Production may have been limited in the fall of 1812 because of repairs to the works. The year 1813 was probably a peak year of production and there is no information to even hint at the yield for that year. In 1814, Ebenezer Meriam supplied the operation with \$20,000 worth of potash. It has been roughly estimated, based on the probable price of potash and the amount of cave saltpeter that this quantity of potash would process, that 115,000 pounds of saltpeter could have been turned out annually.<sup>84</sup> In addition, the operation could have used the wood ashes resulting from the furnace fires as well as potash from Meriam which would have increased yield. Two tourist reports written many years later, do mention production figures of 300,000 to 400,000 pounds, but it is unclear whether they meant an annual yield or production for the entire war.<sup>85</sup>

If all ten vats were operating during the winter of 1811-1812 and Fleming Gatewood's yield estimates are accurate, each vat would have to be filled, leached, and emptied every week and a half. This also means about 1300 bushels of dirt were dug and transported to the leaching stations each week.

#### CAVE SALTPETER AFTER THE WAR OF 1812

With the end of the war in early 1815, the market for cave saltpeter disappeared. As early as the summer of 1814 du Pont urged his agents to slow down on saltpeter purchases and to pay only 18 cents per pound, down from a wartime high price of 38 cents.<sup>86</sup> After the war, cheaper and, presumably, higher quality Indian saltpeter was once again available and the powder manufacturers returned to their pre-war sources. Saltpeter production ended at Mammoth Cave sometime after the end of the war, although some production may have still been underway in 1816.<sup>87</sup> Kentucky gunpowder manufacturers also could not find a market for their products as war surplus flooded the market. The 1820 Census noted that gunpowder produced in Fayette County (Lexington) "Suffers much for want of a market."<sup>88</sup> It was the same around the state. In 1827 E. I. du Pont stated his opposition to the use of cave saltpeter for munitions, proposing that American saltpeter reserves should be

held back to meet needs at the time of future wars, and that in peacetime imports should be used. The government apparently charged no import duty on saltpeter, keeping its cost down.<sup>89</sup>

#### Civil War Saltpeter Needs and Mammoth Cave

During the Civil War, Union blockades of southern ports cut off Confederate supplies of Indian saltpeter for gunpowder. The South had to return once again to cave saltpeter to supply some of its needs, although blockade runners bringing in Indian saltpeter did provide a considerable portion of Southern saltpeter. The Confederate Mining and Nitre Bureau was set up to establish cave mining operations and artificial niteries, such as those used during the Revolutionary War. Caves in Tennessee, Alabama, and Virginia are all documented as being used for saltpeter processing during the Civil War. Kentucky caves were not widely used, since Kentucky remained in the Union, despite much southern sympathy throughout the state. The North had no need for cave saltpeter, since it continued to import saltpeter from India through Great Britain. Although Mammoth Cave lies only about 50 miles from the Tennessee border, the cave served no military purpose during the war.<sup>90</sup>

#### Saltpeter Today

Other events occurred around the world which eliminated the need for cave saltpeter. These included the discovery of saltpeter supplies in Chile and the changing technology of gunpowder and blasting materials.

In 1808, vast quantities of sodium nitrate were discovered in Peru, in an area which is today part of Chile. At first, this discovery did not receive great attention, since there was apparently no way to properly convert the sodium nitrate to potassium nitrate and sodium nitrate made inferior gunpowder. However, in 1857, Lamot du Pont, the nephew of E. I. du Pont, perfected a method to use sodium nitrate in blasting powder which was coming into greater use in mining and construction.<sup>91</sup> In addition, Alfred Nobel perfected nitroglycerin, an alternative for powder, at about the same time. Two separate lines of research continued into using these technologies for munitions. Potassium nitrate saltpeter continued to be used for black gunpowder until the early 20th century, but beginning in the 1860's black powder was gradually supplanted by guncotton and other forms of nitrocellulose. Today, most gunpowder is either nitrocellulose or a mixture of nitrocellulose and nitroglycerine. By the time of World War I, there was little need of potassium nitrate for munitions. At that time, only brief investigations were conducted into the feasibility of using American cave saltpeter for gunpowder.<sup>92</sup>

Today, saltpeter (potassium nitrate) is used in fertilizer, fireworks, and as a food preservative to cure meats and pickle. It is also used in glass making. Most potassium nitrate is made by combining sodium nitrate (Chilean saltpeter) and potassium chloride or nitric acid and potassium hydroxide. The last time cave saltpeter was used in any quantity in the United States was during the Civil War.

### Saltpeter Works and the Tourist Era at Mammoth Cave

With the end of saltpeter production at Mammoth Cave, the obvious value of the cave decreased sharply. However, Gratz and Wilkins did not sell the cave. Archibald Miller, who had supervised the mining and processing operations at the cave, remained at Mammoth Cave to look out for the owners' interests in their property, which by then amounted to about 1500 acres. Miller soon found a new vocation as curiosity seekers came to view the cave. Reports of mummies found at the cave undoubtedly encouraged these visits, and both Gratz and Wilkins were in correspondence with the eastern scientific community about the mummies.<sup>93</sup> In 1828, after Wilkins' death in September 1827, Hyman Gratz purchased Wilkins' half interest in the cave for \$200.<sup>94</sup> Such a price might suggest that Wilkins' heirs felt that the cave was nearly worthless, but of course other business arrangements could have dictated the price. Gratz held on to the cave until 1838 when he sold it to Franklin Gorin, a Glasgow, Kentucky lawyer. Gorin's primary purpose in purchasing the cave was for exhibition as a natural wonder. Interest in Mammoth Cave as a saltpeter producer had ceased.

Although Mammoth Cave had been a tourist attraction since the end of the saltpeter operations about 1816, the purchase of the cave by Franklin Gorin began the era of intensive promotion of the cave as a visitor attraction. In 1828, Hyman Gratz had brought the, by then, elderly Fleming Gatewood back to the cave as manager and Gorin continued to employ him in that position. Gatewood's son, George, became one of the first professional guides at Mammoth Cave.<sup>95</sup> Just a year after buying Mammoth Cave, Franklin Gorin sold it to Dr. John Croghan of Louisville, who was determined that the cave become a tourist attraction. Visitors from around the world began to visit Mammoth Cave and stayed at Croghan's Mammoth Cave Hotel. Dr. Croghan rehired Archibald Miller and his son, Archibald Miller Jr., to operate the cave. Early tourist descriptions of the cave frequently mention the saltpeter works, although not always in a positive light. These negative reactions may have had as much to do with the visitors' fear of entering the dark cave as anything else, like the anonymous writer who described Mammoth Cave as "a fit place for the preparation of death dealing material."<sup>96</sup> These tourist reports, although based on second hand information, provide most of the written descriptions of the saltpeter works. R. M. Bird probably expressed the ideas of other tourists when he wrote that "a factory at Mammoth Cave [is the consummation] of enterprising ambition only to be hoped for by men whose hearts are of gold and silver..."<sup>97</sup> But many others seemed to express pride in the quantity of saltpeter produced at the cave, undoubtedly reflecting information from their guides. The continuing employment of the saltpeter supervisors at the cave must in some way account for the preservation of the saltpeter works, since normally it would seem that they would interfere with the appreciation of the cave as a natural wonder and likely have been removed.

However, not everyone who worked at the cave protected the remains of the saltpeter works. Early tourists also frequently reported that guides used bits and pieces of wood from the works as torches to light up the cave.<sup>98</sup>

Indeed, the Rotunda pumptower is supposed to have been destroyed by a guide's torch in 1903.<sup>99</sup> At some time prior to the late 19th century, the Booth Amphitheatre pumptower was dismantled, perhaps because it obscured the view. The timbers have been used to construct a railing along the tourist trail above the vats. The pump itself is gone. By 1900, photographs show the saltpeter works to appear much as they do today.<sup>100</sup>

#### Mammoth Cave National Park

Dr. John Croghan died in 1849, but the cave continued to be owned by his estate in trust for his nine nieces and nephews. The cave continued under the private ownership of Dr. Croghan's estate until the 1920's, when the last of the doctor's nieces and nephews died.<sup>101</sup> Even before that time, agitation had begun to establish the cave as a national park with the earliest legislation introduced in 1908. Mammoth Cave National Park finally opened in 1941, and the cave and its natural and cultural resources came under the protection of the National Park Service. Just before the cave became a park, Thor Borresen, a Park Service technician, examined the saltpeter works. He prepared drawings, recounted the history of the operation, and noted the condition of the remains in the cave.<sup>102</sup> The saltpeter works today are in much the same condition as noted by Borresen. The saltpeter works are still important stops on interpretive tours of the cave which begin at the Historic Entrance.

#### Suggestions for Further Research

Much more research needs to be done on the Mammoth Cave Saltpeter Works than can be completed during a project of 12 weeks duration.

Additional research is needed on saltpeter production from caves during the Revolutionary War, War of 1812, and Civil War. Although many caves have been looked at, business records and activities of the saltpeter merchants have not received much attention. Historical figures associated with the site, like Archibald McCall, Dr. Samuel Brown, and Charles Wilkins, need further attention. In particular, the relationship of Dr. Brown and Charles Wilkins and the operations at Great Saltpeter Cave could clarify some points in the chronology at Mammoth Cave. Since Great Saltpeter Cave may have been used as a model for the processing operations at Mammoth Cave, additional information on that cave could provide models for hypotheses about Mammoth Cave operations. For instance, the furnaces at Great Saltpeter cave were demolished within recent memory. Descriptions of them might help in understanding the furnace operation at Mammoth Cave, where little remains.

A thorough search should be made for the papers of Charles Wilkins, Hyman Gratz, Archibald McCall, Dr. Samuel Brown, Thomas Hart, Charles Wilkins' brothers John and William, and any of Wilkins' other business partners that can be identified. Archival collections which may have additional information of use are: the Hagley Museum and Library which holds the du Pont papers, the Historical Society of Pennsylvania, Transylvania University, and the National

Archives which may hold pertinent military records. In the early 20th century when the Gratz papers were collected, items relating to Charles Wilkins were located in Cincinnati.

A transcription of the Barren County Circuit Court case, Sterrett & Rice vs. Perkins & Perkins, could provide information on saltpeter operations in the immediate Mammoth Cave area. A cursory examination of these papers showed that Charles Wilkins was active both as a wholesaler and as a producer.

Photographic records of the cave may exist, which might show the saltpeter works in more complete condition than they were in the late 19th century. One collection at the Library of Congress consists of 42 views of the cave, taken in 1866 by Charles Waldack, commissioned by J. Proctor and J. O'Shaughnessy, and published by E. & H.T. Anthony, New York.<sup>103</sup>

A historical archeological survey, both inside the cave and on the surface, could provide further information about the remains and give guidelines for additional work. For example, furnace locations might be found both at Mammoth Cave and at nearby Dixon's Cave. In addition, saltpeter sites at other park caves could be surveyed. A conservation report should be made of the wooden structures in the cave, since they have some degree of dry rot.

A final area needing research is similar industrial hydraulic systems comparable to the water works at Mammoth Cave. The hydraulic system was crucial to processing saltpeter. Since so many parts of it are missing today, this leaves gaps in our knowledge of the operation at Mammoth Cave.

The Mammoth Cave Saltpeter works provided a crucial resource for the American military during the War of 1812. In addition, it is an excellent example of a very early chemical processing operation. It was owned by leading citizens of Lexington and Philadelphia and its products were sold to E.I. du Pont, soon to be a leader in American munitions and chemical manufacturing. That the Saltpeter Works were located in the world's longest cave on what was then the Kentucky frontier adds greatly to the interest of this site.

FOOTNOTES

<sup>1</sup> Robert Montgomery Bird, Peter Pilgrim or a Rambler's Recollections. (Philadelphia: Lea & Blanchard, 1838), 76-77.

<sup>2</sup> Ellis Jones, supervisor of the CCC workers at Mammoth Cave during the 1930s, showed Carol Hill and other members of the Cave Research Foundation remains of the furnace foundation. Duane DePaepe and Carol Hill. "Historical Geography of United States Saltpeter Caves." The NSS Bulletin 43:4 (October 1981), 92.

<sup>3</sup> In the 1960's an air chamber was blasted into the wall of Houchin's Narrows and up to the surface to allow intake of air from the cave to the visitor center and hotel. This has since been blocked off and does not change the size of the cave or any passages.

<sup>4</sup> Duane DePaepe, "Economic Geography of the Mammoth Cave Region Saltpeter Industry," Cave Research Foundation Annual Report (1975), 68.

<sup>5</sup> Duane DePaepe, "Saltpeter Mining Sites in Historic Mammoth Cave," Cave Research Foundation Annual Report. (1977), 47.

<sup>6</sup> Donald Chidsey, Goodbye to Gunpowder (New York: Crown Publishers, 1963), 13-14.

<sup>7</sup> Burton Faust, "Caravans, Caves, and Cannons" II:30. Unpublished manuscript. Burton Faust Collection, Box 2. Department of Library Special Collections, Manuscripts. Western Kentucky University, Bowling Green, Kentucky.

<sup>8</sup> Carol A. Hill, "Origin of Cave Saltpeter," Journal of Geology 89 (1981): 252-259.

<sup>9</sup> Samuel Brown, "A Description of a Cave on Crooked Creek with Remarks and Observations on Nitre and Gunpowder," American Philosophical Society, Transactions 6 (Feb. 7, 1809): 242.

<sup>10</sup> Angelo I. George, "Saltpeter and Gunpowder Manufacturing in Kentucky," The Filson Club Quarterly 60:2 (April 1986): 189-217; Interview with Angelo George, Louisville, KY, July 29, 1986.

<sup>11</sup> Tench Coxe, Statement of the Arts and Manufactures of the United States for the Year 1810, (Philadelphia: A.J. Cornman, 1814).

<sup>12</sup> Donald Hinkley. "American Trade Restrictions during the War of 1812," Journal of American History 68:3 (December 1981): 517-538.

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17 Harold Meloy and William R. Halliday, "A New Concept of the Initial History of Mammoth Cave, 1798-1812," (Mammoth Cave National Park, manuscript, 1968).

18 Rice & Sterrett vs. Perkins & Perkins, Barren County (Kentucky) Circuit Court, Equity Judgement No. 45, 1814.

19 Alexander Wilson, "Letter from Nashville," Portfolio 4 (October 1810): 318.

20 Rice & Sterrett vs. Perkins & Perkins, Deposition of Fleming Gatewood, May 23, 1814.

21 Alexander Clark Bullett, Rambles in Mammoth Cave during the Year 1844 by a Visitor, (Louisville: Morton & Griswald, 1845), 21.

22 Harold Meloy, "Gatewoods at Mammoth Cave" (Mammoth Cave National Park, manuscript).

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25 George Washington Franck, History of Lexington, Kentucky, (Cincinnati: Robert Clarke & Co., 1872), p. 240-241.

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52 Edythe M. Clarke, Bethesda, Maryland to Henry Holman, Mammoth Cave National Park. Letter, November 9, 1981.

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55 Meriam, "Mammoth Cave", 319.

56 John H. Farnham, "Extract from a Letter from John H. Farnham, Esq. A Member of the American Antiquarian Society, Describing Mammoth Cave in Kentucky", Transactions and Collections of the American Antiquarian Society (1820) 356-359.

57 George, "Notes on New Athens Salts Merchants".

58 Carol Hill believes that the crystals which were reported were not saltpeter, but gypsum, as the conditions in American caves were not conducive to crystallizing the nitrates in their natural state.

59 Faust, Saltpetre Maining in Mammoth Cave, 27-28; Carol Hill, "The Mineralogy of Cave Nitrates" The NSS Bulletin 43:4 (October 1981), 127. Hill concludes that nitrate crystals can not exist in humid southeastern caves because the crystals would absorb water from the air, dissolve and re-absorb into the cave dirt.

60 DePaepe, "Saltpeter Era at Mammoth Cave", 20-21.

61 Meriam, "Mammoth Cave", 322; DePaepe, "Saltpeter Era at Mammoth Cave", 17.

62 Interview with Angelo George.

63 Joseph LeConte, Instructions for the Manufacture of Saltpetre (Columbia, SC: Charles P. Pelham, State Printer, 1862); George Washington Rains, Notes on Making Saltpetre from the Earth of Caves, (Augusta, Georgia: Steam Power Press and Chronicle, 1861).

64 The elevation at the bottom of the collecting tank at Booth's Amphitheatre is 576.3. The tank at the Rotunda is 592.3 plus 1.7 feet for the height of the tank wall = 594.0 feet.

65 Interview with Lewis Cutliff, Mammoth Cave National Park, June 30, 1986.

66 Faust, Saltpetre Mining at Mammoth Cave, 53; DePaepe, "Saltpeter Era at Mammoth Cave", 13.

67 The collecting tank is 592.3, the mortises which indicate the platform level are at 607.4. The top of the pump would be about 612.4 and the outlet hole 610.2. Elevation at the gate is 614.9 today.

68 Farnham, 356.

69 Meriam, "Mammoth Cave", 317.

70 Euan F. C. Somerscales, asst. professor of Mechanical Engineering, Rensselaer Polytechnic Institute, to Marsha Mullin, August 1986.

- 71 Bird, "Mammoth Cave of Kentucky", 428.
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- 76 Ibid., 322.
- 77 George, "A Field Trip," 49.
- 78 Meriam, "Mammoth Cave," 322.
- 79 DePaeppe, "Economic Geography," 68.
- 80 Brown, "A Description of a Cave on Crooked Creek," 239.
- 81 Meriam, "Mammoth Cave," 319.
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- 83 Cox, A Statement of the Arts and Manufactures of the United States for the Year 1810.
- 84 Faust, Saltpetre Mining, 72-74.
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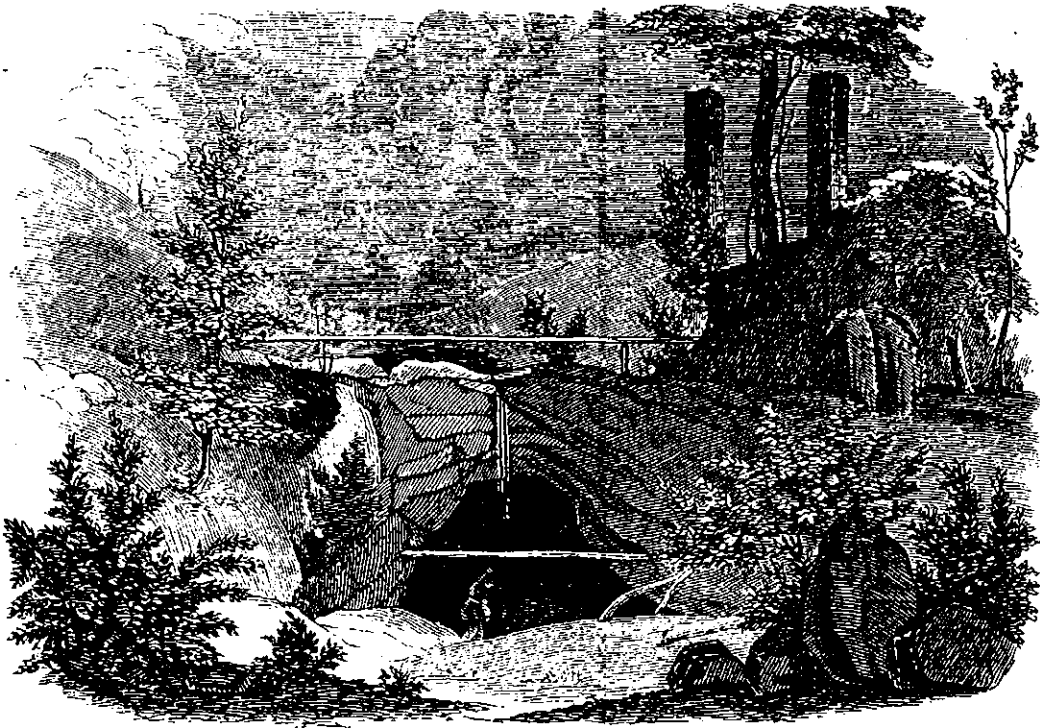
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This view of the Booth's Amphitheatre pump tower appeared in  
"Mammoth Cave, Kentucky," Ballou's Pictorial Drawing-Room Companion  
8:20 (May 19, 1855) p. 309.

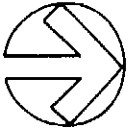
The artist has moved the pump tower, probably because it would  
otherwise obscure the view of Gothic Avenue.



Cave entrance showing beam across entrance supported by rock ledges. Two furnace chimneys can be seen in the background. It is likely that the artist moved these chimneys to suit his artistic composition and that the furnaces were actually closer to the entrance.

This view of the cave originally appeared in: Bird, Robert M., "The Mammoth Cave of Kentucky," The American Monthly Magazine 3 (May 1837) p. 428.

This version of the illustration is from: Cary, Alice. "The Mammoth Cave," The National Magazine 9 (December 1856) p. 511.



MAMMOTH CAVE:  
HISTORIC AREA  
0 200 400 600 FEET

